# THE CAGED TIGER OF TECHNOLOGY: KNOWLEDGE BASED SYSTEMS AND TECHNOLOGY TRANSFER IN SMES

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## ABSTRACT

Knowledge-based Systems (KBS) are one of the most commercially exploited area of artificial intelligence today. Advances in this discipline mean that emerging technologies are in a mature state to be exploited by industry. In fact KBS applications have been described by the Japanese as the Caged Tiger of Technology meaning that the market is set to explode in the near future.

This is a realisation that has been central to the success of the Northern Ireland Knowledge Engineering Laboratory (NIKEL). The Laboratory was established three years ago in collaboration with International Computers Limited, through initial assistance from the European Community. Today it is flourishing with a staff of 15 Researchers working on a wide range of KBS applications for industrial partners. KBS techniques are being applied to improve substantially business processes including contract tendering, factory scheduling, fault diagnosis and production-control in both small enterprises and multi-national corporations.

Given that Northern Ireland has a population of 1.6 million and an economy heavily reliant on SMEs, the ability of NIKEL to deliver commercial results in a competitive business environment has been central to its success. This success has resulted in the emergence of an innovation culture among industrial partners which in turn has greatly contributed to their economic prosperity. Over the last two years the laboratory has extended its customer base beyond Northern Ireland to establish both research and commercial projects with companies and universities throughout Europe, the United States and China.

This paper outlines the success achieved in utilising an approach that combines Business Process Re-engineering (BPR) with Knowledge Based Systems (KBS) development. A case study is presented which explains how this method has encouraged a local manufacturing company to embark on strategic research and development activities.

## KNOWLEDGE BASED SYSTEMS

A KBS is a computer program that contains specialist or expert knowledge to assist in problem-solving (4). It differs from conventional programs because 'knowledge' is usually encoded using high-level formalisms. These formalisms include rules, facts, objects, cases, etc. The source of the knowledge for a KBS may come from an expert / experienced personnel, manuals, online databases, or any valid data source. The development of a KBS usually requires a range of *knowledge engineering* techniques including knowledge acquisition, knowledge elicitation and prototyping.

The focus of development in KBS is the move from traditional rule based systems containing the accumulated knowledge of domain experts to systems that fully utilise vast quantities of corporate data. Consequently, eventual applications incorporate the intelligence residing in the organisation.

The Northern Ireland Knowledge Engineering Laboratory (NIKEL) is a flourishing centre with a staff of 15 Researchers working on a wide range of KBS applications with industrial partners. Through collaborative projects, KBS techniques are applied to improve business processes such as contract tendering, factory scheduling, fault diagnosis and production-control in both SMEs and multi-national corporations.

Northern Ireland has a population of 1.6 million and an economy heavily reliant on SMEs, therefore the ability of NIKEL to deliver commercial results in a competitive business environment has been central to its success. This success has resulted in the emergence of an innovation culture among industrial partners which in turn has greatly contributed to their economic prosperity. Over the last few years the laboratory has extended its customer base beyond Northern Ireland to establish both research and commercial projects with companies and universities throughout Europe, the United States, Hong Kong and China.

## SMES AND TECHNOLOGY TRANSFER

Entrepreneurship and innovation play a significant role in the success of enterprises of all sizes. It is recognised that economic growth depends on a capacity to develop a strategic competitive advantage, and that this requires sophisticated approaches and appropriate technological infrastructures (1). Fast growing, dynamic small companies have a greater ability to implement change and adapt and employ new technologies than larger more traditional organisations. Moreover government policy in both Europe and the United States has placed emphasis on supporting start up firms and small companies (2) (3).

In Northern Ireland, 93% of firms employ less than 10 people. These firms can gain competitive advantage by bringing on board new leading-edge technologies and business strategies. A strategic management tool which has emerged recently is business process reengineering (BPR). BPR can provide a supporting framework that makes the introduction of new technologies such as Information Technology (IT) and in particular Knowledge Based Systems (KBS) technology, more effective economically, and with less risk than that usually associated with IT investment.

Knowledge based systems have been described by the Japanese as the Caged Tiger of Technology meaning that the market is set to explode in the near future. KBS are a powerful force for technological change and advancement in all types of organisations and businesses. KBS can add value and provide benefits such as consistency in decision making. Until recently, their introduction to an organisation was a difficult process, mainly because techniques used lacked a business-orientated operating framework. BPR is not a panacea for IT and KBS development, but it does shift the focus onto the business, how it operates, its weaknesses and its strengths, etc. This results in an analysis where IT and KBS may be targeted into processes and areas where maximum value may be obtained.

The area described in this paper outlines the benefits to be gained for an SME from the application of KBS using BPR as a functional supporting framework.

## TECHNOLOGY AND BUSINESS PROCESS AUDITING

Companies in Northern Ireland make heavy use of a Government scheme that provides 50-66% funding support for Technology Audits. These audits enable management of NI SMEs to appraise their technology needs, shortfalls and strengths. The audits frequently outline a company’s core operational business processes, providing an explicit and documented snapshot that provides NIKEL

with a valuable starting point for organisational analysis, and enables the technique of Business Process Reengineering (BPR) to be more easily applied.

## BUSINESS PROCESS REENGINEERING

BPR is a methodology that enables an organisation to make fundamental changes in the way it carries out its business. In BPR, the focus moves from function to process where, for example, traditional functions such as sales may be overhauled, simplified and reconstituted as processes. Supporters of BPR advocate that the reengineering of a company's important business processes should be a revolutionary event (7), and not evolutionary or revelationary. However, recent work on practical application of BPR (8) suggests that an evolutionary approach, more recently called *morphostatic* BPR (9), may be more acceptable to management and staff than the revolutionary, or *morphogenic*, approach. The morphostatic approach may act to prepare an organisation for the more rigorous application of morphogenic BPR. For this reason, morphostatic BPR is sometimes termed *first order* BPR, while morphogenic BPR is termed *second order* BPR.

The rewards of BPR are 'across the board' improvements in value, quality, customer support, and productivity; which are achieved by the new business processes possessing inherent flexibility, agility and responsiveness.

## USING KBS TECHNIQUES WITH BPR

BPR is facilitated through the application of appropriate Information Technology (IT). Historically, IT has enabled business processes within functional areas of companies such as manufacturing. However, this application of IT makes the a priori assumptions that companies are optimally organised already, and that the functional approach can manage change elegantly. As a result, adding IT to the existing functionally-based processes can guarantee only to computerise non-optimal processes that will be difficult to change.

In new, lean business processes where non-value added tasks have been removed, IT can enable manufacturing philosophies, e.g., Optimised Production Technology (OPT) or Just-In-Time (JIT). However, complex problem areas will still exist in reengineered companies. These problems will occur with large and small companies, and basic IT cannot address them. They include the handling of incomplete, conflicting and vague data, the discovery of knowledge in massive data sets, the interpretation of legislation and inter-organisational contracts, the management of change, and the reapplication of an expert's accrued experience and expertise. KBS techniques provide a series of tools that can help to assess, manage and ameliorate these problems (10)(11). Knowledge engineering, which is the name given to the process of building KBS, applies specialised techniques to acquire, represent and use business process knowledge. There have been a number of reported successes where KBS have added value to business processes (12)(13), and in fact made their reengineering possible in the first place.

## SME CASE STUDY: PERFECSEAL LTD

Perfecseal Ltd, is a medical packaging manufacturing company located in Northern Ireland and employs 150 people. They have been working closely with NIKEL to develop software that takes knowledge about shop floor processes, to improve customer choice and manufacturing performance. This has given the sales force an awareness of the development problems associated with manufacturing a particular order, and ensures that any new quotation given can feasibly be manufactured using existing equipment. Like many SMEs, the company is split

into 'functional' areas such as Production, Finance, Sales, Customer Service, Production Engineering etc. As the company expanded, increasing numbers of sales queries and orders resulted in many different functional areas being consulted in response to customer enquiries. This resulted in delayed response times, potential duplication of effort, and inconsistent responses emanating from different functional areas. As a consequence, the company suffered reduced effectiveness in a number of key areas (see Table 1 below).

It was apparent that some kind of re-engineering process needed to be conducted and BPR was the preferred approach. The introduction of a BPR approach enables the individuals who use the output of the processes (product feasibility assessment, product engineering & quotation) i.e., the salespeople and customer services, to actually carry out the process - via the aid of a knowledge-based automated rapid response system.

The approach used was morphostatic BPR, where a systematic redesign is adopted. Although based on the existing process, this approach is much easier to implement incrementally. This involved identifying and understanding the existing processes associated with the order life cycle, then systematically working through them to add value to existing processes and create new more efficient processes. The objective was to:

- Eliminate all non-value adding tasks;
- Simplify the remaining tasks;
- Integrate remaining tasks;
- Automate as much of the process as possible.

| **Problem Area** | **Explanation** |
|---|---|
| Order Cycle time | The length of time to 'process' a new order increased. |
| Time taken to quote | Increase in time taken to perform an initial quotation, resulting in a potential loss of customers. |
| Feasibility assessment | A job could be quoted and an order placed before engineering had judged it feasible. |
| Modelling | Increased time taken for customer changes in order and calculating the consequences for order feasibility and price. |
| Errors in Order | Due to human error, the more human contact in the order chain, then the increased likelihood of human error entering the order. |
| Duplication of data | As each functional area required common data, this was often duplicated. |
| Inconsistent Data | Lack of co-ordination meant different functional areas were sometimes using different 'standard' figures for their costing formulas, etc. |
| Wastage | Due to human error, and inconsistent data / procedures, the 'optimum' product routing and material selection may not always be selected, resulting in unnecessary wastage. |
| Inaccurate Quotes | Due to lack of confidence in the quotation system, the sales force would sometimes change prices without consultation with the company. |

**Table 1 - Problem areas**

It was felt that a multi-department, cross-functional project would pay the greatest rewards in terms of speed, efficiency, and customer satisfaction.

A series of knowledge elicitation interviews were conducted with staff from each of the functional areas to identify and extract the processes involved within and between the functional areas, with a view to specifying and constructing an automated rapid response system which traversed and integrated all of these areas. A Knowledge Document was constructed, containing the interview transcripts and flowchart descriptions of processes interpreted from the interviews. The automated system was constructed using an 'evolving' rapid prototyping approach, which facilitated additional knowledge extraction from the process owners/experts as well as confirming, verifying and validating their earlier knowledge.

The Rapid Response System runs on the PC Network in the company, and on the laptops carried by the sales force. It consists of a knowledge base that contains the shop floor knowledge elicited from interviews, and a number of data bases that hold the information the knowledge base requires to operate.

It is implemented in Visual Basic, Access, with links to the MAPICS manufacturing system running on an IBM AS/400.

What were previously separate functional departments (production, planning, customer services, accounts, quality, engineering) have now been dissolved. Employees from each of these functional departments now combine to form 'business units'. The result is a totally self-sufficient structure which operates not on a functional level, but instead focuses on the processes involved across the entire manufacturing cycle. The employees within the 'units' are cross-trained.

This re-structuring, combined with KBS/IT (Rapid Response System) support has led to the following improvements:

- Increased integration of all parts of the sales operations (distribution, pricing, invoicing, settlement, accounting and ordering).
- Shorter quotation/order cycle times has been the most measurable outcome from the implementation of the rapid response system.
- The 'automation' aspect in itself has eliminated existing paper-based ordering, quoting and specification processes and has electronically linked tasks enterprise-wide that sales reps have traditionally performed manually.

From management's point of view the major benefits resulting from the BPR exercise as a whole, and more specifically the introduction of the rapid response system are that the expertise and knowledge concerning all areas of the business has been spread throughout the company as opposed to being localised in previously functional areas. Furthermore, under-pricing previously presented management with problems. The rapid response system now quickly determines a price which is based on actual production costs that would be incurred rather than a first guess by the sales person. Significant deviations from this 'derived' price must be justified by the sales person, and stored with the quote. The pricing process is now more consistent and more importantly, economically accurate. The managers can now use the rapid response system as a modelling tool to investigate pricing consequences of various routing and specification configurations.

From a sales staff point of view the major problems that the BPR exercise is intended to solve are slightly different - as they have different priorities. These are as follows:

- Keeping track of the current (most up-to-date) price quoted to a customer.
- Time taken to re-quote based on changed customer specification or different order quantities.

- Check tooling availability.

During the development of the rapid response system a number of challenging issues arose. A major task was to try and order and structure the task of selling, this is a highly individualistic activity. Staff became a bit uneasy about the implementation of the rapid response system, this is an inevitable result with the threat of job losses that could result from automation of intra- and inter-functional processes.

## CONCLUSIONS

The main objectives of the case study company were to reduce order cycle time, reduce errors, reduce costs and improve the quality of customer service. The automation of these processes required the introduction of knowledge-based techniques.

The case study illustrates how an organisation can use KBS in BPR to orient itself towards and support the customer. It shows how KBS techniques manage key parts of the business processes, providing access to high-level company knowledge and empowering the employees to deliver high quality and highly consistent decisions. It also shows that BPR is a suitable technique for introducing the leading-edge technology required by SME firms to remain competitive. Neck (14) states that "…to secure and maintain growth in SMEs, the following criteria must be met: maintaining product, adhering to customer requirements, introducing cost-effectiveness and efficiency in production, consistency and reliability, adhering to delivery schedules and changing the mindsets of entrepreneurs to think globally". BPR provides the framework for this to happen, and KBS is an enabling technology that can operate within this framework.

In general, successful SMEs see the expertise and knowledge of their employees as their most valuable asset. This paper has shown that this valuable knowledge may be embedded within IT in a knowledge based system that supports the reengineered business processes. To conclude, effective use of new technological developments (such as KBS) is a key success factor for today's competing SME. In the case study KBS technology allowed the SME to become more competitive by harnessing its valuable experience and expertise in a cost-effective manner. Research laboratories like NIKEL enable SMEs to effectively access innovative technologies coming out of universities.

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